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Letter to the Editor

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Response to Unit conversions between LOINC codes

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We applaud the work of Hauser et al.,[1] who have realized the potential for converting result values associated with one Logical Observation Identifiers Names and Codes (LOINC) term to those associated with another through mathematical operations. They applied these transforms to pairs of terms in several categories, including those expressed as molar versus mass units, simple counts on different scales, linear versus log values, and 2 terms that are inverses of each other. The authors also listed several interesting, but more problematic, conversion pairs, some of which might be grist for future work. They carefully researched all of the conversions and verified a few exemplars with a clever empirical test. Their approach to conversions can simplify the presentation of flowsheets and the aggregation of data for research purposes. Finally, they called attention to one LOINC lithium code, which carried an example unit of "mol/L" when it should be "mmol/L." We are grateful for their careful review. We found 2 other lithium terms that needed the same correction, and these updates will appear in the December 2017 LOINC release.

We highlight the fact that the units of measure included within the LOINC table are neither normative nor necessarily inclusive of all appropriate units for a given test. We hope they are representative of what is usually reported, but can only assert that they are examples, which is reflected in the names of the fields in the LOINC table (*EXAMPLE_UNITS* and *EXAMPLE_UCUM_UNITS*) and in the technical documentation. The values in these fields are populated based on the units provided by the requestor of the LOINC term and have also been augmented by feedback from the user community. While appropriate use of LOINC does not mandate that specific units should be used, it does require that reported units of measure should be consistent with the *Property* of the term. That is, the units reported for a given term must all be dimensionally equivalent. Therefore, if the *Property* is **mass concentration** (mass/volume), the reporting units should have a mass unit in the numerator and a volume unit in the denominator, eg, "mg/dL" or "mcg/L." Units of "mmol/L" or "mg/24 h" would not be allowed for mass concentration terms, because the first has a molar unit in the numerator rather than a mass unit and the second has a time unit in the denominator rather than a volume unit; instead, these units represent **molar concentration** (moles/volume) and **mass rate** (mass/time), respectively. As Hauser et al. illustrated, discrepancies between the *Property* of a LOINC term and the reported units of measure for a test signal a potential problem, either with the mapping to LOINC or with the units being reported for that test result.

The Unified Code for Units of Measure (UCUM) units[2] in the LOINC table use the standard syntax that has been adopted by many large standards organizations, including the Institute of Electrical and Electronics Engineers, Digital Imaging and Communications in Medicine, Health Level-7, and International Organization for Standardization 11240, the last of which is part of nomenclature adopted by Big Pharma. UCUM has a formal syntax that can be validated and a matrix of coefficients that define all legal conversions between values expressed in one unit to values expressed in another commensurate unit. A number of freely available UCUM validation and conversion tools exist.[3–5] For a given test, UCUM conversion routines will convert values reported in one commensurate unit to another. These conversions are widely applicable, but are general conversions, because they operate solely on knowledge of the "from" and "to" UCUM unit strings. Further, we hasten to add that these UCUM conversion tools do not address any of the more difficult conversions (eg, mass to molar, inversions, linear values to log values) tackled by Hauser et al. These authors set a very high bar for the next generation of unit conversion routines.

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